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Abstract

THE BEHAVIOUR OF UO_2 AND OF $(U, Pu)O_2$ FUEL MATERIALS UNDER IRRADIATION

by

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This paper includes the results of several recent studies of the course of radiation damage in oxide fuel materials and of pre-irradiation characterisation of $(U,Pu)O_2$ solid solutions. Thermodynamic and crystallographic data indicate that single-phase solid solutions are preserved under strongly reducing conditions, and also under mildly oxidising conditions at high temperatures, if the ratio $Pu/(U + Pu) \leq 0.35$. The thermodynamic results are used to discuss the precise composition reached by oxides during preparation and in use and the chemical form of the fission products.

Crystallographic evidence indicates the formation of stable clusters of defects at doses of 5×10^{18} fissions/cm^3 during irradiation at 70°C and at 400°C; most of the damage anneals in several stages between 200 and 700°C. Volatile fission products - I, Te and Cs - move as fast or faster through sintered UO_2 at 1400°C as do rare gas atoms; the introduction of Pu has little intrinsic effect on gas emission. Electron microscopy reveals the migration of pores to grain boundaries during irradiation. The evidence is consistent with the concentration of fission products at grain boundaries, even at low temperatures. Radial temperature gradients have been measured during irradiation; thermal conductivity (K) values do not change appreciably at doses up to 5×10^{19} fissions/cm^3 and mean temperatures of above 500°C, but K values decrease during irradiation at lower temperatures.

Miniature fuel elements of UO_2 have been irradiated to burn-ups of 2 to 5.7% over a range of centre and surface temperatures. Fission gas release varied

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from 0.2 to 68% but no gross dimensional changes were observed. Evidence of some plastic flow was obtained during irradiation to 5.7% burn-up at estimated temperatures lower than 1300°C.

The behaviour of $(Pu_{0.01}\ U_{0.99})O_2$ solid solutions has been compared with that of UO_2 in irradiations at low burn-up and centre temperatures up to 2300°C, and $(Pu_{0.10}\ U_{0.90})O_2$ was tested along with UO_2 to a burn-up of 0.9% at centre temperatures below 1275°C. The introduction of Pu had no deleterious effect in either case; gas release was similar for the UO_2 and $(U,Pu)O_2$ oxides and the $(Pu_{0.1}\ U_{0.9})O_2$ pellets were less cracked than the UO_2 pellets.